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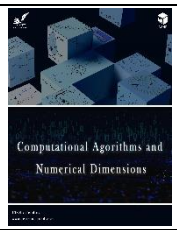

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Smart Parking by Using Sensor Network

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Abstract

Humanity is currently experiencing one of the short periods of transition thanks to novel sensing solutions for smart cities that bring the future to today. Overpopulation of cities demands the development of solid strategic planning that uses infrastructure, innovation, and technology to adapt to rapid changes. To improve mobility in cities with a larger and larger vehicle fleet, a novel sensing solution that is the cornerstone of a smart parking system, the smart vehicular presence sensor (SPIN-V, in its Spanish abbreviation), is presented. The SPIN-V is composed of a small single-board computer, distance sensor, camera, LED indicator, buzzer, and battery and devoted to obtain the status of a parking space. This smart mobility project involves three main elements, namely the SPIN-V, a mobile application, and a monitoring center, working together to monitor, control, process, and display the parking space information in real-time to the drivers. In addition, the design and implementation of the three elements of the complete architecture are presented.

Keywords: Smart parking, IoT, Wireless sensor network.

1 | Introduction

Nowadays, several applications in scientific areas such as medicine, agriculture, social sciences, and computer sciences, as well as non-scientific areas, such as government, society, and industry, among others, have been boosted by the implementation of Internet of Things (IoT) techniques [1]. IoT is expressed in diverse areas that are classified according to the problems that can be solved, e.g., those in health, agriculture, networks, cities, and sports, among others. Future sensing solutions will be embedded in large automation systems, such as smart factories, buildings, and cities [2].

Many cities around the world have already started implementations of smart parking projects, making life easier. Intelligent parking helps drivers too efficiently and effectively searches for parking spaces through information and communication technology [3]. In addition, intelligent parking spaces are systems that optimize the way of parking, either by streamlining the process or by reducing the space required. This proposal seeks to implement an attitude of respect towards the environment [4].

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Many proposals are working on this approach. Some of them require using the Global Positioning System (GPS) to know the available locations [5]. Other works focus on making reservations without ensuring the space availability. In this work, a new parking system is presented [6]. The proposed system is composed of three elements. The first is the development of an Intelligent Vehicular Presence Sensor (SPIN-V, in its Spanish abbreviation) installed in parking spaces, which stores, processes, and notifies the state of a parking space [7]. The second is the intelligent parking system (SEI-UVM, in its Spanish abbreviation); it is available through a mobile application to monitor and manage parking spaces and also allows users to make reservations of any available space [8]. The third is a monitoring center that gathers information about the complete system, users, and SPIN-V sensors [9]. A case of study of the sensor functionality is presented and compared with the existing ones. In the next section, some of the most representatives' proposals in this area are presented [10].

2 | Literature Review

Smart Parking Applications: The proposed SEI-UVM is a smart parking system that is devoted to private parking lots and composed of three main elements: the SPIN-V, a mobile application, and a monitoring center [11]. Each parking space is equipped with a SPIN-V located in the middle of the backend of parking spaces. The mobile application is available for the user/driver to control and reserve a parking space while the monitoring center can be operated by the owner of the private parking lots to manage and control the parking spaces and the reservations [12]. The information shared by the app is stored in a database and observed by the monitoring center at OBNiSE. All the information is sent from the SPIN-V to the cloud. In addition, the exchange of information is available through WiFi protocol communication [13].

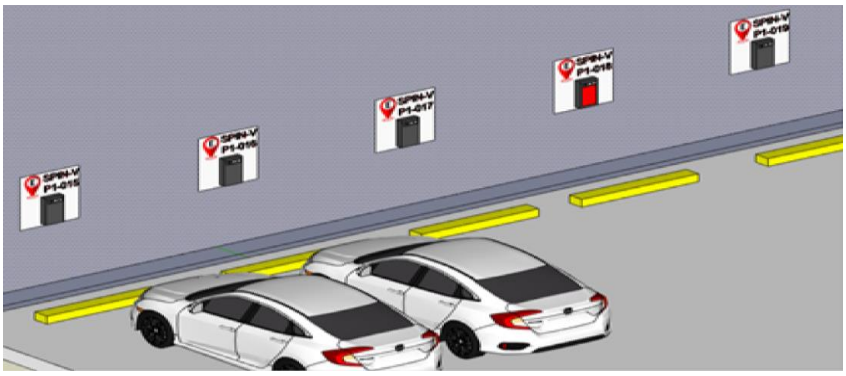

Fig. 1. Smart parking technical guide.

Smart Parking Sensors: There are various sensors which facilitate in detecting parking occupancy information and these are mentioned in the following sections [14]. Sensors are one of the common tools which were widely tested in several previous literatures. Descriptions of these sensors are mentioned in the following [15].

Ultrasonic Sensor: These sensors would emit sound waves between 25 to 50 kHz and detect objects based on reflected energy[16]. Ultrasonic sensors are used primarily. They can be found in automobile self-parking technology and anti-collision safety systems [17]. Ultrasonic sensors are also used in robotic obstacle detection systems, as well as manufacturing technology [18]. In proximity sensing applications, ultrasonic sensors are not as susceptible to interference of smoke, gas, and other airborne particles (though the physical components are still affected by variables such as heat) [19].

3 | Discussions

This novel sensing solution of the SPIN-V as a cornerstone of the SEI-UVM has been designed and developed as a compact device and adaptable to different environments since it can be used without the need for an expensive infrastructure installation, unlike the solutions of the current guided systems [20].

The three main elements of the SEI-UVM working together in the proposed architecture open the possibilities to bring business, product development, marketing and sales together, improving innovative product management [21].

It should be noted that the sensing solution of the SPIN-V was made with the integration of sensors in the market; the energy consumption is not optimized in this version and it will be added in future work [22]. More advanced technologies in terms of power consumption have to be taken into account for the second version of the SPIN-V. Besides, a service provider for the IoT such as Sigfox should be considered to connect the SPIN-V with the digital universe [23]. Furthermore, some issues related to the effectiveness of the license plate identification algorithm should be improved. For instance, the sensitivity of the proposed solution to environmental light conditions must be considered throughout the implementation of the algorithm, as well as during the positioning of the camera and the overall system. Situations such as occlusions or direct exposure to sunlight must be handled properly by the system. On the other hand, despite the robustness of the text detection algorithm, high perspective distortion must be avoided as it can prevent the system from the text detection. Smart Parking Technologies: Sensor technologies are tools which facilitate the driver in occupying a vacant parking space and descriptions of these technologies can be found in the following sections below.

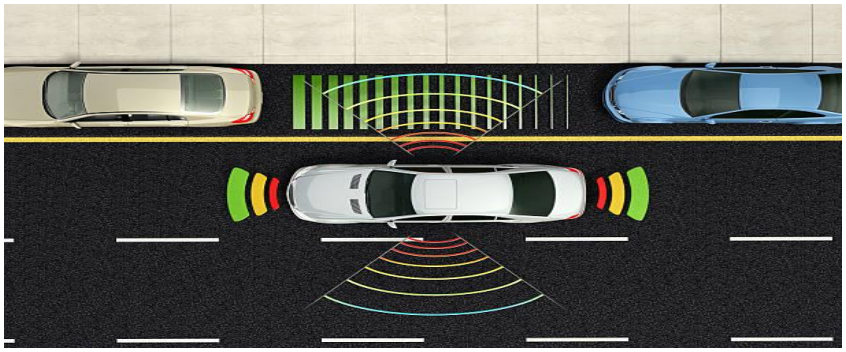

Fig. 2. Sensor communication.

Fig. 3. Vacant space detection through sensor.

4 | Conclusions

The proposed architecture of the solution of the SEI-UVM is divided into three main blocks: SPIN-V, the mobile app, and the monitoring center (OBNiSE), where the key piece is the SPIN-V IoT sensor. It is designed as a compact device that can be adaptable to different environments and does not need an expensive infrastructure installation. In addition, it allows solving the challenges of non-vision systems (individual vehicle control through the reading of the text of the vehicle license plate) and in particular the advantage over visual systems as the infrastructure installation cost is much lower, since it does not require of a wiring system. In addition, the text recognition process of the plate is carried out in the SPIN-V device then only the text is upload to the cloud instead of an image or video. In summary, the SEI-UVM allows distributing the reserve management to the users and it is able to gather

more information and communication with the user. Finally, the OBNiSE provides the management of the parking spaces status to be consumed by the mobile app.

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